



The retrofit of stone-built grade II listed buildings using Passivhaus techniques – is this possible?

BSc Building Surveying

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Methodology

The research will explore the importance of net zero homes and the use of Passive homes to help reduce the carbon emissions used in domestic homes and whether we can use Passivhaus techniques to reform grade II listed buildings. The researcher will undertake this research by using several methods which include exploratory research that seeks to gain a greater understanding of the topic area and use for future projects. The secondary research that will be used by the researcher will include library-based research using certified articles, sustainability journals and official reports and handouts documented by the Passivhaus trust. The research will also be undertaking conference participation as another form of secondary research. In relation to ethical concerns with this research, efforts must be made to ensure the protection of conflicting interest which means throughout any of the research, the research must always remain unbiased. The researcher will obtain informed consent from any participants taking part and keep all information obtained confidential and anonymous. The relation to data collection using online sources will be correctly referenced and all information clearly displaying the official authors credentials using Harvard referencing structure.

1. Introduction

Climate change is accelerating at rapid paces from many contributors. Carbon Dioxide (CO₂) being one of the “most dominant greenhouse gas” (*Rosado, 2020*) with “2.7 tonnes of carbon dioxide” being emitted from UK Homes each year (*Citu, 2022*). Therefore, as we move forward in reducing the amount of greenhouse gases we produce within our homes when we use energy, we must not forget about the historic past. As we move forward with new domestic buildings it is important that we incorporate our knowledge and technology in to listed buildings which are defined as grade II, incorporating the history, and keeping the external appearance as much as possible. Buildings currently consume around 85% of energy by using only its heating, lighting, and heating of its domestic water supply. (*M.Mihai et al, 2017*) and with the European Union deciding that buildings energy consumption must be reduced by 20%, changes need to be made. This report hopes to find out whether it is possible to retrofit, grade II listed buildings into passive homes making them future proof for climate change and government goals of becoming net zero. The report will be based around whether it would be possible for stone built listed buildings to have necessary passive home alterations and what this would entail and whether it would be possible to do so with all current restrictions. Weather and climate have been taken into consideration during this report, to identify whether climates and weather patterns can affect the results of passive homes.

2. Global warming

Climate change has been driven by humans and their everyday activities, especially their constant burning of fossil fuels such as coal, oil, and gas (*United Nations, 2021*). The growing cause for concern of global warming has never been more of an education point as it is now due to greenhouse gases being their highest rates in two billion years according to the United Nations and the world is now 1.1 degrees Celsius warmer. These evident figures shown indicates that now more than ever we need to act on global warming.

3. *What is Net Zero*

Net zero is referring to “the state in which the greenhouse gases going into the atmosphere are balanced by removal out of the atmosphere” (*University Of Oxford, 2022*) Net zero comes hand in hand with “To go net zero” which creates this ultimate target and goal for all to achieve and strive towards

4. *What is a passive house?*

Passive homes are designed to provide maximum amounts of comfort all year round and can be heated or cooled with the use of very minimal energy usage. The building envelope of a passive house is the main focus of the design, it's extremely airtight- envelope and using a 'Heat Recovery Ventilation system known also as a MVHR or a an alternative high-tech ventilation system, these are there to continuously supply the home with high quality fresh air without the need for opening and closing windows, the ventilation system evenly heats or cools the home on the interior using the air supply within the home, keeping the heat at a constant temperature internally despite external hot or cold periods and seasonal months (*M.Mihai et al , 2017*). Passive homes incorporate passive solar gains into their designs which uses the absorption of solar radiation converting these rays into energy for the home's usage.

4.1. *Passive Houses- Apparent advantages and disadvantages*

The apparent advantages of a passive house are easily identified as a Socio-economic and environmental cost benefit, with its low-cost energy efficient way of heating and powering homes, along with a vast contribution to becoming net zero by reducing the carbon dioxide released into the atmosphere. On the other hand, with the extensive design and use of high tech system to ensure full capability of the passive home and the use of high quality energy efficient materials such as its insulation and ensuring its air tight envelope, it can be deemed a large costly short term expense and costly procedures in relation to the design and build process as a whole, Although the long term expenses will show the home repaying its short terms costs by low energy consumption and money saving on energy usage. In a recent online article by (*Alter, 2021*) they argued that passive homes may never payback their initial costings due to the cost of energy being so low for a prolonged period of time although with the recent hike in energy costs, this has change Alters perspective who claims that a thirty year payback time is likely for a passive home in the year of 2021. In contrast with another interview, (*Sharp, 2021*), stated her perspective that passive homes immediately payback on their costs “Because when you are in a comfortable, well designed and balanced space it can improve your family's quality of life right-away”. These conflicting opinions, show valid points in relation to how affective the passives homes can be in cost returns.

Additional disadvantages circling around passive houses as detailed by (*McLeod, Robert S et al , 2019*) who cautioned that there may be an increased risk of overheating within a passive house especially within the near future as increased temperatures are rising from global warming. They have stated there may be serious consequences with adverse health effects caused by overheating.

4.2. The requirements for a passive home

Passive homes are equipped with high tech and efficient materials, along with intelligent construction. Passive homes require high quality insulation, special windows and doors which are manufactured to prevent large amounts of heat loss. These items of a passive home are made with airtight designs with no ability of thermal bridging and high amounts of mechanical ventilation and equipment. All these requirements are needed to have a home qualify as a passive home (*Marcus, 2021*). Solar panels are a crucial source of supplying renewable energy, along with heat pumps, although these only need to supply the home with the remaining energy as the main source of heating demands are from heat sources and extracted air that comes from running household appliances as explained by (*Burdett, 2017*).

5. Building Characteristics in a stone built listed building

Stone built historic buildings were the greatest achievement in respect of designs and appearance, weight and durability during the medieval period, and a point of overall structural strength. Stone is an extremely durable construction material, tough against wind, fire, water, decay, and insects. The typical constructions of a stone built historic building does vary with alternative ages from the 1900s way of stone construction. They would have typically been erected as two outer leaves bonded together with copious amounts of lime mortar or alternatively for wealthier builds, rubble would be tightly bonded together to form a strong single skinned wall. The use of cavity walls and insulation did not get introduced until the mid to late 19th century therefore it would be very unlikely to find one of these types in a listed building.

5.1 Stone thermal abilities

Typically, the construction of a stone wall is not adequately equipped with great thermal abilities and can be inefficient as these typical stone walls allow both heat and cold through to the interior. Using a past article from (*Mary Felix Et Al, 2017*), they complete an investigation testing thermal efficiencies within different climate zones, although the majority of the articles compares the warmer climates, there is a climate zone focus on stone heating and cooling space within thermal efficiencies, after analysing their data, you can clearly see that stone built walls of 20cm thickness, in terms of total energy consumption, stone built buildings are satisfying the necessary consumption needed, overall meaning that stone buildings are great at retaining and insulating heat, however, stone walls may take that little bit longer to heat up initially.

6. Grade II listed buildings – including their restrictions of repairs and adaptations.

Listed buildings are classified as a building which has a specific past, historic background or is of an architectural importance. This means that listed buildings are subject to tight restrictions which ultimately protect the buildings historic background and exceptional character. Listed buildings can be banned in such matter if located in an area of special heritage or interest (*Johnson, 2020*). There is an act governed by law known as the “Planning (Listed Buildings and Conservation Areas) Act 1990”. This act governs listed buildings and buildings of historical interest as well as providing restrictions of work which preserve the building itself and maintains its features.

Grade II listed buildings are those which most buildings fall into. These grade II listed buildings allow for subtle work helping to preserve the building without changing its original features.

6.1. Repair and adaptations restrictions

Grade II listed buildings allow for little repairs and upkeep and are exempt from the requirement for listed building permission. There is a need for permission before doing anything that is considered to be a "material modification." Simple solutions like painting external doors and windows a different colour could fall under this category. (Alan Boswell Group, 2022).

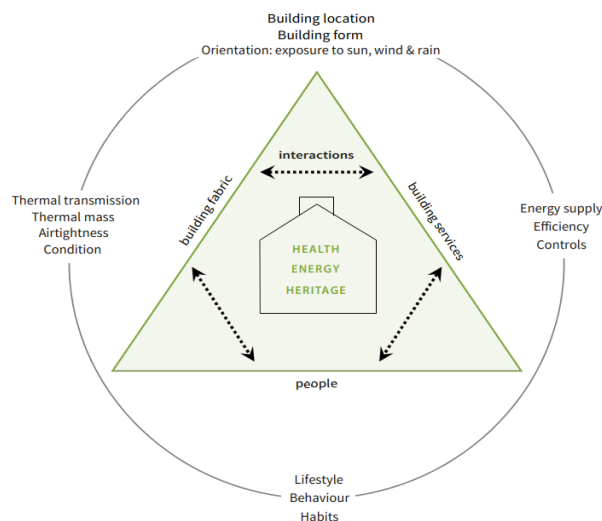
There is a need for consent for the following modifications:

- Replacing windows or doors.
- Painting a building's exterior
- Roof repairs / replacement.
- Erecting a new building or structure within the listed building's curtilage.
- Building an extension, porch, or conservatory
- Creating a fence, gate, or wall.
- Exposing timbers or brickwork.
- Adding solar panels or wind turbines.

There is major concern for grade II listed building in relation to modifications if they intend to change the external features of the building. These following modifications are those which are unlikely to be allowed as suggested by (Alan Boswell Group, 2022)

- Removing architectural features
- Stone cleaning
- Adding pipes, flues, or alarm boxes
- Removing boundary walls or gates.
- Repointing using the incorrect materials.
- Removing chimney stacks or pots.
- Painting or rendering stonework.

Additional limitations and restrictions can take place in the form of deterioration, building regulations and planning permission from the local planning authority. Listed buildings are



labelled 'listed' after a long period since its construction. During these long period of time, large contributions from time, natural disasters, air quality which could accelerate the deterioration of the exterior building envelope, abandonment, adverse weather conditions and building deformities are shown. As with all other buildings within the UK, listed buildings are not exempt from building regulations, and require more than just building

regulations, they also require approval of documents and a stringent process of planning permission, which unambiguously accepts that special considerations are needed for these historical buildings. (*Historic England, 2022*). Using this diagram presented by (*Historic England, 2018*) it shows that “no one size fits all” however there are principles which can be enforced and those below are the fundamental principles:

- Identify its significance
- Research local environment and climate
- Initial design and construction of the building
- Current fabric performance
- Intended building use and occupancy
- Available resources; financial and materials
- Identify the constraints

It is noted that attempting small repairs can vastly increase the buildings envelope efficiency without damaging its retaining building envelope. Attempting to make listed buildings more energy efficient, requires a need for care and a gentle approach in relation to ensuring the value of the building is sustained for the future generations.

7. Geography and temperature affecting a Passive house.

Passive homes as described in the previous sections of this report defining these types of homes to be tight building envelopes with mechanical ventilation ensuring the home is constantly heated to a comfortable temperature, within this section it will endeavour to understand how different climates, both hotter and colder climates can affect passive homes and whether different forms of mechanical ventilation must be used to withstand those differing climates.

7.1. Mediterranean climates

As with all Mediterranean climates, summer and winter climates prevail, bringing with them different temperatures, conditions, moisture levels, humidity, and adverse weather conditions, which can be caused with the majority of the above. All these conditions may result in beneficial impacts or negative impacts on passive home techniques.

Mediterranean climates during the winter are usually cooler with periods of rainfall followed by lesser amounts of sunny weather. Summer months pose large amount of sunny, hot weather with high humidity levels.

7.2. How are buildings designed within a Mediterranean climate

Homes built within a Mediterranean climate are usually designed with its local style with the emphasis on the home as a refuge and sanctuary is present in all forms, even though they differ, and they all provide simple access to the outside through large doors and windows, terraces, atriums, and patios. (*TAYLOR, 2022*). There are key features that Taylor states that are included within Mediterranean homes as part of their design criteria, these include:

- A connection and seamless change from interior to outside
- A feeling of space produced by high ceilings and arches.
- Red-tile roofs
- Rough-hewn wood or carved doors
- Brick

➤ Stone

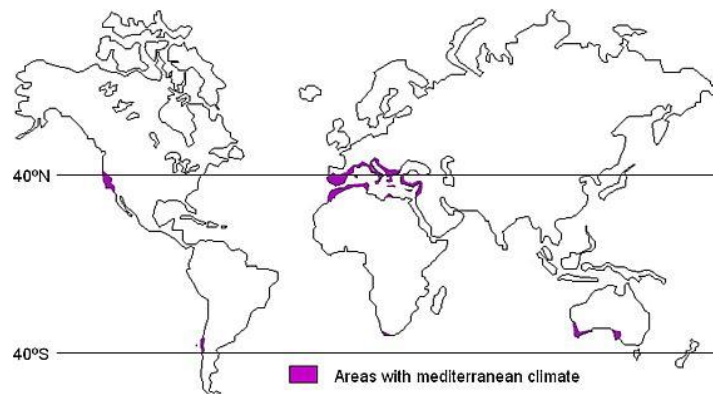


Figure 1- Showing the areas with Mediterranean climate 31 - 40 degrees north and south of the Equator
<https://www.mediterraneangardensociety.org/climate.html>

Humidity within the summer months with a Mediterranean climate can reach medium to high humidity through its summer months and around no humidity to low humidity within its winter and cooler months.

7.3. Colder climates

Northern Europe has been assigned for investigation for this report, a study into how cooler climates affect passive homes with either a positive or negative impact. Cooler climates can be resembled to the UK climate in relation to some of the months. In a recent research article by (Patrik Rohdin *Et al*, 2014) they stress the increase in windy weather and storms which increase the overall draught level throughout a home in this climate. Therefore, the concern shifts from overheating in the hotter climates to extreme precautions in relation to air tightness around the building envelope in the cooler climates.

7.4. How are buildings designed within a colder climate such northern Europe

There is not too much difference in weather climates from the UK to Northern Europe due to the similar locations from the equator. The design focus is very similar, Buildings are well equipped and focus more on stability and protection from the external weather conditions. Strong structures along with fully insulated cavity walls and full equipped rooms for each climate.

8. Successful passive home case studies within the UK- Results and analysis

8.1. Lark Rise Case Study

The UK is now home to over 1,300 passive homes (Tim Pullen *et al*, 2022), using the Passivhaus Trust online facilities, it is encouraging to see how many projects of passive homes have become successful within the UK. This helps keep focus and encouragement that there may still be opportunity to create the next projects of passive homes within the listed building sector. Each project shown on the Passivhaus documents, show remarkable success in residents' satisfaction, providing a self-servicing and maintaining homes, recycling all parts of its used energy as well as using the most of its natural surrounds to produce its own energy power. Using the 'Lark Rise' case study from Passivhaus trust, this is a large cold farmhouse containing 2 bedrooms in a guest house, this property is a

detached project of approximately “175m²” floor area, situated on a northwest facing slopes of hills in Buckinghamshire. (*Bere, 2018*), The architect expressed the main challenge of incorporating the openness of the site, using the current landscape to the homes advantage by “cutting the house into the slope” as well as partially burying the home to ensure it keeps a low profile so that it can enhance the landscape it currently holds. Mr J. Bere also stressed within his interview with Passivhaus trust (*Passivhaus Trust, 2018*) that the values of the home being self-efficient and independent have been achieved or at least on track to becoming successful years after monitoring. The performance outcome has shown that the thermal energy demand was predicted at 14.54kWh/m² a year however actual data shows its energy demand was only at 7.11 kWh/m² a year with a demand of 37 kWh/m² in renewable energy demand and generating way over the demand by generating 79 kWh/m² per year.

8.2. New Farmhouse

This project within the Passivhaus trust combines yet another rural property with limited energy resources which resulted in being quite costly. As seen clearly in the (*Passivhaus Trust, 2013*) The New Farmhouse was created to solve the costly energy costs but having the property use its natural resources to run itself. The farmhouse is equipped with a “domestic hot water systems using a heat to air pump” and the use of the continuous wind will be utilized and used to create energy for the house to use. This project won a ‘Passivhaus Trust Award 2014’. The sustainability of the home presents energy demand of 101 kWh/m² and heat demand of 13kWh/m² as well as incorporating heat strategies from electric and wood fuelled appliances and a “shading strategy of deep-set windows”.

Conclusion

9. Overall conclusion

To conclude this research project of passive homes, have very specific requirements for orientation, location, and climate. These requirements can impact the effectiveness of a passive home. This research project had focused on grade II stone built listed buildings in the UK, with comparison to other countries within Mediterranean climates and northern Europe to see whether hotter and colder climates are beneficial for passive homes, from this research it has shown that both hotter and cooler climates can have relatively similar outcomes although working at different capacities, For example within a hotter climates the equipment used to power a passive home would have to work a lot harder to regulate the temperature and reduce a high amount of humidity, whereas within a cooler climate, it would be easier to regulate a consistent temperature without working the equipment to its maximum, however with cooler climates, they are subject to a lot of adverse weather conditions including storms and windy weather condition, this could pose issues for the likely hood of draught and that is why there is a higher need for adaption to ensure the building envelope is fully sealed. Hotter climates and passive homes would require additional work to ensure that due to the external weather conditions and high humidity levels which can be constant over a long period, can be set at a safe and comfortable level, according to the Environmental Protection Agency (*EPA, 2023*) the most comfortable level is below 60 however ideally, they suggest a percentage level of between 30% – 50%. There

is a concern of overheating which can be highly dangerous to the occupants if it has gone unnoticed, with failure of equipment, this could pose a significant threat to life. Further research has shown that within these hotter climate's designs are built and constructed to blend in with local and surrounding architecture, however this means that the design needs to include the spacious living with easy access and adaptations to the interior and exterior. Passive homes, however, are designed with tight building envelopes using machinery to power the home regardless of the external temperature and for this the open plan element of incorporating interior with exterior would be restricted. The high ceilings and arch ways may also pose difficulty to creating a passive home due to larger amounts of heating within the cooler months to ensure constant temperature all year round which could overwork machinery is not monitored or powered correctly. Listed buildings are historic buildings some that have been weathered with age and some in better condition than others and for that, structural strength differs hugely between all or the majority of listed buildings dependent of their previous uses and the preservation they have been given, Passive homes are equipped with vast amount of machinery, technology and multiple layers within its building envelope all of which add additional weight onto a structure which may have not have had the structural strength to hold this. It is likely that large amount of structure work will need to be undertaken to ensure they are able to withstand any additional weight its future purposes. In the above research, Lastly, I have included case studies, these hopefully will help in showing that passive homes can be constructed with incorporation of their surroundings which overall will hope in reassuring that the natural and historic surroundings can be incorporated. Although, listed buildings have their restrictions, using the discussion on this in section 4.2. it has shown that passive homes are created by using these requirements, all of which can be done by altering more of the interior than the exterior. There is a concern that with passive homes using solar panels as a source of renewable energy, as well as a heat source pump which are located on the external of the building also, which would spark more investigation into whether solar panels and alternative designs for heat source pumps which can be created especially for listed buildings, increasing their potential in becoming passive homes.

Reflective account

This research proposal has formed part of an interest taken prior to my studies however ever more of an interest since studying. Passive homes were a topic that sparked interest for myself as I participated in a conference earlier this year, this conference highlighted key matters such as net zero and development of passive homes. I took both interests of passive homes and listed buildings to create a question in which formed this research project. Throughout this research it has educated me on these key matters of net zero and the impact of global warming and climate change, all of which contribute to the need for vital changes that need to be made sooner rather than later. The idea of becoming net zero and the government target of meeting this requirement by the year 2050, stressed the importance of reducing the effect of climate change. Personally, this project has taught me that the way we live our everyday lives creates a significant impact on climate change. Professionally, it has created this urge to encourage all large participating parties i.e., construction industry to change the way they conduct their projects, taking more considerations to the built surroundings, using the environment and its surroundings to

create a sustainable environment but more importantly encouraging a more practical way of construction for the future.

The journey to my research has incurred successes and failures throughout. Some of the failures include the access to some information which I had found difficult to create answers to some of my research questions. Another failure is statistical data was not readily available due to the uniqueness of this project which although was a great topic to discuss, posed difficulty finding this information. The research has been successful with creating a unique research project which can hopefully be used to contribute to climate change and highlight the importance of adaptations and reuse of buildings, more specifically listed buildings. To resolve the issues, I faced with my failures, I had to conduct a lot of electronic research, more than I would have wished, as the information had not been readily published. However, I managed to use some research papers and combined online research from these to create answers to my project.

If I were to conduct this research again, I would take on more research in the form of interviews with passive house and listed building experts to incorporate their knowledge on the topic and discuss their thoughts on this research proposal. Using this form of research, would have helped establish topics which I may have not discussed, that could have helped create an alternative outcome. It would have also helped gather expert knowledge on how the public see listed buildings, as some people would not like to see a listed building become anything other than what it was built for originally, therefore trying to stratify all parties, may be the reasons that a listed building may not make it to becoming a passive house with disagreements and arguments stating that it would be changing its character. Another change I would make would be to take on independent testing for thermal performance, so that it would create data in which I could specifically use to analyse and use this data to create more accuracy in the project, with this in mind, I would enhance the research by conducting investigation and testing on thermal performance of different types of stones, to find out what stone quality would best suit the thermal performance of a passive home. This research has strengthened my ambition to create uses for listed buildings, by preserving them and creating them into a home, however, also maintain their historic background for the future generations to study.

Overall, this research has helped in identifying a possible career choice that I can start once I have completed my studies. By starting a career in this field, I will hopefully be creating a sustainable future proof environment, be part of achieving the government target of becoming net zero by the year 2050.

8. References

Alan Boswell Group, 2022. *Guide to Grade II listed building restrictions*. [Online]

Available at: [https://www.alanboswell.com/news/grade-2-listed-building-restrictions/#:~:text=There%20are%20many%20things%20you,unless%20there%20are%20exceptional%20circumstances\).](https://www.alanboswell.com/news/grade-2-listed-building-restrictions/#:~:text=There%20are%20many%20things%20you,unless%20there%20are%20exceptional%20circumstances).)

[Accessed 24 February 2023].

Alter, L., 2021. *Is It Payback Time for Passive House?*. [Online]

Available at: <https://www.treehugger.com/is-it-payback-time-for-passive-house-5204761>

[Accessed 2023 February 2023].

Bere, J., 2018. *Lark Rise* [Interview] 2018.

Burdett, R., 2017. *Passive House*. [Online]

Available at: <https://renewableenergyhub.co.uk/blog/passive-house/#:~:text=This%20allows%20most%20of%20the,associated%20with%20a%20passive%20house>

;

[Accessed 03 April 2023].

Citu, 2022. *What is the carbon footprint of a house?*. [Online]

Available at: <https://citu.co.uk/citu-live/what-is-the-carbon-footprint-of-a-house>

[Accessed 25 November 2022].

Concrete Renovations , 2019. *What are the Differences Between Grade I and II Listed Buildings?*. [Online]

Available at: <https://www.concreterenovations.co.uk/news/what-are-the-differences-between-grade-i-and-ii-listed-buildings/#:~:text=What%20is%20a%20Grade%20I,is%20placed%20on%20such%20sites.>

[Accessed 2022 November 25].

EPA, 2023. *What Is the Ideal Indoor Humidity Level at Home in Summer?*. [Online]

Available at: <https://www.weatherstationadvisor.com/ideal-summer-indoor-humidity-level/>

[Accessed 2023 April 2023].

Green Building Store, 2020. *What is Passivhaus*. [Online]

Available at: <https://www.greenbuildingstore.co.uk/information-hub/what-is-passivhaus/>

[Accessed 25 November 2022].

Hiscox, 2016. *Grade II Listed Building Regulations*. [Online]

Available at: <https://www.hiscox.co.uk/home-insurance/cover-stories/grade-ii-listed-building-regulations/#:~:text=Grade%20II%20listed%20buildings%20are,consent%20from%20the%20relevant%20authorities.>

[Accessed 2022 November 25].

Historic England , 2022. *Building Regulations, Approved Documents and Historic Buildings*. [Online]

Available at: <https://historicengland.org.uk/advice/technical-advice/building-regulations/#:~:text=Listed%20buildings%20or%20buildings%20in%20conservation%20areas%20are%20not%20exempt,regulations'%20approved%20documents%20covered%20below.>

[Accessed 28 February 2023].

Historic England, 2018. *Energy Efficiency and Historic Buildings*. [Online]
Available at: <https://historicengland.org.uk/images-books/publications/eehb-how-to-improve-energy-efficiency/heag094-how-to-improve-energy-efficiency/>
[Accessed 03 March 2023].

Johnson, B., 2020. *What can you do to a Grade II listed building?*. [Online]
Available at: <https://www.yopa.co.uk/homeowners-hub/what-can-you-do-to-a-grade-ii-listed-building/#:~:text=What%20is%20a%20Grade%20II,which%20protect%20its%20unique%20character.>
[Accessed 14 January 2023].

Krämer, K., 2016. *The first Passive House: Interview with Dr. Wolfgang Feist*. Kranichstein: Internation Passive House Association.

M.Mihai et al , 2017. *Energy and Buildings*. [Online]
Available at: <https://pdf.sciencedirectassets.com/271089/1-s2.0-S0378778817X00078/1-s2.0-S0378778817308290/main.pdf?X-Amz-Security-Token=IQoJb3JpZ2luX2VjEB4aCXVzLWVhc3QtMSJGMEQCIGXe5X552aMkkSiGTP5rJ7qe7nRjJgHYpc6uOxWH3buAiBvoLX0ggOTIMBYtDxca4XqHOTXTfJ0ncZKLtk4w8lgSrV>
[Accessed 10 February 2023].

Marcus, S., 2021. *A guide to Passive Houses: designs, costs and savings*. [Online]
Available at: <https://www.ovoenergy.com/guides/energy-guides/passive-house>
[Accessed 03 April 2023].

Mary Felix Et Al, 2017. *The Efficiency of Using Different Outer Wall Construction*. [Online]
Available at:
<https://reader.elsevier.com/reader/sd/pii/S1876610217322282?token=29015EF0DAAB2B678232BCDC0CF63418B73031AFAC3B103147716DB62D12C52D3802ABCE37CF90A1F6BA34132D8783E4&originRegion=eu-west-1&originCreation=20230303132151>
[Accessed 03 March 2023].

McLeod, Robert S et al , 2019. *An investigation into future performance and overheating risks in Passivhaus*. [Online]
Available at: <file:///C:/Users/aye-s/Desktop/Uni%20Work/Work%20Based%20Project/Assignment/Reading%20Lists/McLeod%20Hopfe%20Kwan%20-%20overheating.pdf>
[Accessed 2023 February 10].

Passivhaus Trust , 2013. *New Farmhouse*. [Online]
Available at: <https://www.passivhaustrust.org.uk/projects/detail/?cId=56>
[Accessed 03 March 2023].

Passivhaus Trust , 2018. *Lark Rise*. [Online]
Available at: <https://www.passivhaustrust.org.uk/projects/detail/?cId=93>
[Accessed 03 March 2023].

Patrik Rohdin Et al , 2014. *Experiences from nine passive houses in Sweden*, Sweden : Elsevier.

Rosado, H. R. a. M. R. a. P., 2020. *Greenhouse Gas Emissions*. [Online]
Available at: <https://ourworldindata.org/greenhouse-gas->

emissions#:~:text=Greenhouse%20gases%20are%20measured%20in,CO2e%20each%20year
[Accessed 2022 November 25].

Sharp, S., 2021. *Is It Payback Time for Passive House?*. [Online]
Available at: <https://www.treehugger.com/is-it-payback-time-for-passive-house-5204761>
[Accessed 04 May 2023].

TAYLOR, L. H., 2022. *17 Breathtaking Mediterranean Homes*. [Online]
Available at: <https://www.thespruce.com/breathtaking-mediterranean-homes-4688755#:~:text=Key%20features%20of%20Mediterranean%20home%20design%20include%3A%201,wood%20or%20carved%20doors%208%20Brick%20More%20items>
[Accessed 20 February 2023].

Tim Pullen et al, 2022. *Passivhaus: How to Build to This Low Energy Standard*. [Online]
Available at: <https://www.homebuilding.co.uk/advice/passivhaus>
[Accessed 04 May 2023].

United Nations, 2021. *What Is Climate Change?*. [Online]
Available at: <https://www.un.org/en/climatechange/what-is-climate-change>
[Accessed 25 November 2022].

University Of Oxford, 2022. *WHAT IS NET ZERO?*. [Online]
Available at: <https://netzeroclimate.org/what-is-net-zero/>
[Accessed 2022 November 25].